

IN THE SPECIFICATION:

Please replace paragraph [0007] with the following amended paragraph:

[0007] During the plating process, copper ions are continually being removed and replenished to/from the electrolytic solution, and therefore, the copper concentration of the electrolyte inherently changes or varies over time. This concentration change may further be affected by volume depletion of the plating solution and/or dissolution of the anode. Additionally, plating operations also deplete the various organic molecules in the electrolyte solution, and therefore, the organic concentration also varies over time. For example, levelers are known to deplete/breakdown upon exposure to oxygen containing elements, *i.e.*, ambient air, oxygen absorbed into the plating solution, oxygen molecules contained in the anode metal, or oxidation encountered during plating by incorporation into a growing film. This breakdown process generates free radicals in the plating solution, which are undesirable, as the free radicals can deposit on a substrate and contaminate the metal layer. Further, levelers are known to breakdown upon exposure to copper, copper alloys, and/or platinum, all of which are typical anode materials for electroplating systems. Similarly, accelerators and suppressors may also suffer from depletion/breakdown characteristics as a result of oxygen and/or metal exposure. Depletion of organics is not limited to processing time periods, as the electrolyte solution in electroplating ~~system~~ systems is generally continually circulated through the plating cell, storage unit, and potentially a replenishment device during non-processing time periods. As a result of the circulation, the plating solution may be continually exposed to both oxygen-containing elements and the metal anode. Therefore, as a result of this exposure, the organic molecules in the plating solution are continually being depleted, ~~eventhough~~ even though the plating system is not in a plating or operational mode.

Please replace paragraph [0012] with the following amended paragraph:

[0012] Embodiments of the invention further provide a method for reducing organic

depletion in an electrochemical plating system during non-processing time periods. The method generally includes the steps of closing an electrolyte feedline ~~now~~ in order to isolate a plating cell from electrolyte supplied during a non-processing time period, and draining at least a portion of the remaining electrolyte solution from the plating cell by opening a bleed valve in fluid communication with the plating cell.

Please replace paragraph [0020] with the following amended paragraph:

[0020] Figure 2 is a perspective view of an exemplary electroplating system platform 200 of the invention. Figure 3 is a schematic plan view of the exemplary electroplating system platform 200 of the invention. Referring cooperatively to Figures 2 and 3, the electroplating system platform 200 generally includes a loading station 210, a thermal anneal chamber 211, a spin-rinse-dry (SRD) station 212, a mainframe 214, and an electrolyte replenishing system 220. The mainframe 214 generally includes a ~~mainframe transfer station 216~~ having a plurality of processing stations 218. Each processing station 218 may include one or more processing cells 240. An electrolyte replenishing system 220 is generally positioned adjacent the electroplating system platform 200 and individually in fluid communication with each of process cells 240 in order to circulate fresh electrolyte thereto that will be used for the electroplating process. The electroplating system platform 200 may also include a control system 222, which may be a programmable microprocessor-type controller configured to interface with the various components of system platform 200 and provide controlling signals thereto. Control system 222, for example may be used to control parameters associated with the plating process, such as electrical bias applied to a substrate, duration of substrate exposure to electrolyte solutions, rotation rates of substrate support members, flow rates of electrolyte into plating cells, flow rates of organic molecules into the plating solution via the replenishment module 220, actuation of valves related to the plating process, *i.e.*, check valves and bleed valves, along with other parameters generally associated with the execution of the semiconductor processing recipe in a plating apparatus. Loading station 210 generally includes one or more substrate cassette receiving areas 224, one or more loading station transfer

robots 228, and at least one substrate orientor 230. The number of substrate cassette receiving areas 224, loading station transfer robots 228, and substrate orientors 230 included in the loading station 210 may be configured according to the desired throughput requirements of the particular system.

Please replace paragraph [0028] with the following amended paragraph:

[0028] Additionally, although current densities of 10 to 15 A/cm² are illustrated in the exemplary method of Figure 7, the invention is in no way limited to these current densities. Rather, it is contemplated that the method of the present invention may be applied to a wide range of current densities. It is to be noted, however, that generally the range of current densities implemented in the test runs will be determined by the normal operational current density range of a plating process or apparatus. For example, if a particular plating operation or apparatus generally operates using current densities in the range of 35 to 55 A/cm², then the test runs may be adjusted to incorporate this current density range. Similarly, if the normal operation range for a plating system uses current densities between 2 A/cm² and 2.2 A/cm², then the test runs may be conducted at 2, 2.05, 2.10, 2.15, and ~~2.2 A/cm²~~, for 2.2 A/cm², for example. Therefore, generally speaking, the range of current densities utilized in the test runs may be determined by the normal operational current density range used in the plating process of a particular processing recipe or plating apparatus, regardless of the magnitude of the current density.

Please replace paragraph [0029] with the following amended paragraph:

[0029] Once the test run process is complete, the method of the invention generally includes calculating the volumetric depletion of organics per unit of time for each current density implemented in the test runs, as illustrated in step 2 of Figure 7. This calculation, which is briefly discussed above, generally includes determining the volumetric depletion of the concentration of organics in the plating solution during the individual test runs. Once the volumetric depletion of organics is determined, the

volumetric depletion may be divided by the time duration of the test run at the particular current density in order to yield the volumetric depletion of organic material per unit of time for the respective current density. As illustrated in Figure 7, for example, for the 14 A/cm² current density test run, it may be determined from the concentration change of organics in the plating solution that the volumetric depletion of organics from the plating solution is ~~40~~ 50 volume units. The volumetric depletion may then be divided by the duration of the test run to determine the volumetric organic depletion per unit time. For example, for the 14 A/cm² test run it was determined that ~~45~~ 50 volume units of organics were depleted from the plating solution over 20 units of time. Therefore, dividing ~~45~~ 50 volume units by 20 units of time yields an organic volumetric depletion per unit time of 2.5. The calculation of the volumetric depletion per unit time may be repeated for each individual current density used in the test run process. As such, the volumetric depletion per unit time may be calculated for each current density that may be used in the operation of the plating system.

Please replace paragraph [0030] with the following amended paragraph:

[0030] Once the volumetric depletion per unit time is determined for the respective current densities used in the plating system, i.e., for each test run, then a processing recipe implemented in the plating system may then be modified and/or adjusted to include real-time replenishment of the depleted organics during the plating process. For example, as illustrated in step 3 of Figure 7, an exemplary processing recipe having four individual recipe steps therein (A, B, C, and D[,]) ~~and E~~) may be modified to include real-time replenishment of depleted organics within the individual recipe steps. Within recipe step A, for example, it may be determined from the test run that using a current density of 10 A/cm² requires organic replenishment of 2 volumetric units of organics per unit time. Therefore, during the five units of time of recipe step A, organics may be replenished into the plating solution at a rate of 2 volumetric units of organics per unit of time, as step A operates at 10 A/cm², and this current density has been found to deplete 2 volumetric units of organics per unit of time in the test run process. Therefore, although the plating operation is depleting organics at a rate of 2 volumetric units per

unit time, the present invention is simultaneously replenishing 2 volumetric units of organics into the plating solution during the plating process. Therefore, the resulting organic depletion rate in the plating solution is nullified, as the organics being depleted from the solution are simultaneously being replaced by a replenishment process. Further, the organic concentration gradient may be minimized, as the concentration of organics generally will not vary using the present invention. The replenishment process may continue through the remaining recipe steps (B, C, and D) in a similar manner to that described for step A. For example, during the 10 units of time of recipe step B, 25 volumetric units of organics may be replenished into the plating solution, as it was calculated from the test run that 2.5 volumetric units of organics are depleted per unit time from the plating solution while the plating process is operating at a current density of 14 A/cm². Similarly, during recipe steps C and D, 11.5 and 10 volumetric units may be replenished into the plating solution, respectively.

Please replace paragraph [0034] with the following amended paragraph:

[0034] With a substantial portion of the electrolyte solution removed from processing region 475, and with processing region 475 isolated from the remaining volume of electrolyte solution in the plating system, the depletion of organics during the non-processing time period is minimized. The minimized depletion of the organics is a result of the electrolyte solution neither flowing over the anode 470 nor contacting oxygen containing elements. Rather, the bulk of the electrolyte solution is maintained in an electrolyte storage container positioned proximate the plating apparatus 400 and is not continually circulated through the plating cell 475. Inasmuch as electrolyte circulation during non-processing time periods results in a substantial portion of the electrolyte depletion during non-processing time periods, electrolyte.

Please replace paragraph [0035] with the following amended paragraph:

[0035] Once the non-processing time period is over, plating apparatus 400 may be returned to a processing mode. The transformation from the non processing time

period to a processing mode may generally include a starter or initialization phase. For example, the starter or initialization phase may be configured to refill the processing region 475 with fresh electrolyte prior to commencing plating operations. As such, the initialization phase may include opening of check valve 477, such that fresh electrolyte may begin to flow into and fill up processing region 475. The filling process may include leaving bleed line 479 open, such that fresh electrolyte may be allowed to flush processing region 475, i.e., fresh electrolyte may be pumped into processing region 475 by fluid supply line 476, while electrolyte is simultaneously being removed from processing region 475 by bleed line 478. As such, processing region 475 is flushed of the portion of electrolyte that remained therein during the non-processing time period, i.e., the old electrolyte that was used to maintain the anode immersed in fluid during the non processing time period may be removed. Once processing region 475 is flush to the old electrolyte, bleed valve 479 may be closed, and therefore, processing region 475 may be supplied with fresh electrolyte from supply line 476 for normal plating operations. Alternatively, another bleed line may also be positioned in a lower portion of processing region 475, and therefore, this additional bleed line may be used to simply ~~dumped~~ dump the old electrolyte from processing region 475 during the initialization process in this embodiment, once the old electrolyte is dumped from processing region 475, check valve 477 may be opened ~~in~~ and fresh electrolyte supplied to processing region 475 via fluid supply line 476.

Please replace paragraph [0036] with the following amended paragraph:

[0036] In another embodiment of the invention, replenishment of organics may be undertaken via a real-time measurement process. For example, a plating system controller may be in electrical communication with a measurement device, i.e., a cyclic voltammetric stripping device (CVS). The measurement device may be configured to take a real-time measurements of the electrolyte plating solution, and more particularly, to take real-time measurements of the concentration of specific organics within the electrolyte plating solution. These real-time measurements taken by the measurement device may then be transmitted to the system controller. The system controller may

process the measurements taken by the measurement device, which generally represent specific organic concentrations in the plating solution, and compare the measurements to a target organic concentration stored in a memory of the system controller. Using the comparison, the system controller may determine an appropriate volumetric replenishment of the specific organic measured by the measurement device. This determination made then be used by the system controller to control a chemical cabinet in fluid communication with the electrolyte plating solution, such that the chemical cabinet may dispense an appropriate time varying volume of the organic, such that the concentration of the organic in the electrolyte plating solution is maintained at or near the target organic concentration. Therefore, in general, the system controller may be implemented in a closed loop type configuration, where the system controller receives a measurement from a measurement device, ~~process~~ processes the measurement to determine an appropriate replenishment volume, and then generates a control signal to be transmitted to a chemical cabinet, wherein the control signal is configured to control the chemical cabinet to replenish a measured element. This configuration generally operates in a real-time manner, in that the measurements are taken real-time, i.e., during processing or within a processing recipe step, and further, that the replenishment is conducted real-time, i.e., within a processing recipe step or during processing. However, it is to be noted that the closed loop type embodiment of the present invention is not limited to any particular system controller and/or measurement device, as it is contemplated within the scope of the present invention to use various system controllers and/or measurement devices known in the semiconductor art.